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The Real Option Value of Patent Infringement

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Nearly every air traveler has at some point weighed the relative benefits of a cheaper, non-changeable ticket against a more expensive, flexible ticket. Similarly, a hotel room that does not offer a refund in the event of a cancellation is usually less expensive than a pre-paid hotel room for which a refund is available. The value of flexibility (or in some instances "optionality") is well known to consumers, in business,[1] or even in sports.[2] Simply put, the best option available to me tomorrow might not align with the best option available to me today. I am often willing to pay a premium for a product that maintains my flexibility to adjust to changing conditions, and I typically will prefer to delay a decision that might reduce my future flexibility.

Of course, my flexibility will impose some expected costs on the party with whom I am doing business. While I hold a ticket that I might not use, the airline cannot sell my seat. If I do not use the ticket, the seat could potentially remain empty. In exchange for potential lost revenue, the airline will charge a higher price for the ticket. If I use the ticket, I pay a premium for its use. However, when I cancel my travel plans, the airline could go unpaid if it is unable to sell the ticket to another traveler.

When a firm practices a patent without first executing a license, it is exercising a type of option similar to the flexible ticket. Just as I do not know

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[1] *See, e.g.*, Marvin Denis, Sebastian Kohls, Pieter Peeters & Zachary Silverman, *Building Optionality: Balance Sheet Discipline Is Both Timely and Timeless*, McKinsey & Co. (Apr. 21, 2023), https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/building-optionality-balance-sheet-discipline-is-both-timely-and-timeless.

[2] *See, e.g.*, Proby Shandilya, *Optionality in Sports*, Medium (July 27, 2021), https://probyshandilya.medium.com/optionality-in-sports-ca031f3efd86.

whether I will need to travel using the purchased ticket, the firm might not know whether it needs to obtain a license to the patent claiming inventions. If the product is commercially unsuccessful, it is less likely that the patent will be asserted against the product, and the firm will face no penalty for its infringement. If the firm's product is commercially successful, the potential damages it would face for infringement are based on the price it would have paid had it procured a license to the patent at the time of first infringement. In other words, there might be no incremental costs to the implementer to delaying the licensing decision.

In practice, few firms begin the development of a new product with a patent search and licensing negotiations. That is not to say that willful patent infringement is ubiquitous. A firm might not know where its research and development process will lead it. A product might not infringe a patent until it is used for a specific purpose, in conjunction with specific other products, or consumer feedback on early iterations of the product causes specific infringing modifications to subsequent iterations of the product. Regardless, the infringement creates for the infringer a valuable option to wait to obtain a license to the patented technologies. As I explain below, a framework for patent damages that does not include the value of that option will undercompensate the patent holder. However, the existing framework can and should account for that option value. The inclusion of an option value is consistent not only with the Patent Act, but also with the analysis of a hypothetical negotiation at the time of first infringement. Just as the airline passenger pays extra for the flexible ticket, an infringer would be willing to pay for an option to delay its licensing of the infringed patent.

This article seeks to identify and value the infringer's option to wait, a feature of patent-infringement damages that the literature on reasonable royalties has largely left unaddressed. Prior scholarship has recognized that legal rules can sometimes confer option value on infringers, particularly in the lost-profits context, but that literature does not develop a corresponding account of how the hypothetical negotiation should price the option created by delaying a license under the reasonable-royalty framework. Jerry Hausman, Gregory Leonard, and Gregory Sidak showed why option value matters when courts assess noninfringing alternatives.[3] Yet even when damages are measured by a reasonable royalty, the law can still grant the infringer a valuable right to defer payment until uncertainty resolves, and that right should be priced rather than assumed away. In that sense, this article extends the closest comparable work and offers a new account of how real-options logic fits within the ordinary law of patent damages. Jeffrey Blumenfeld identified

[3] Jerry Hausman, Gregory K. Leonard & J. Gregory Sidak, *Patent Damages and Real Options: How Judicial Characterization of Noninfringing Alternatives Reduces Incentives to Innovate*, 22 Berkeley Tech. L.J. 825 (2007).

the harm from purportedly "efficient infringement" and patent holdout when holders of standard-essential patents (SEPs) commit to offering SEP licenses on fair, reasonable, and nondiscriminatory (FRAND) terms.[4] This article focuses on non-FRAND patent licensing, but the inclusion of the real option value in a FRAND setting will similarly reduce the incentives for holdout and free riding by implementers.[5]

The practical implications are substantial. If the option to wait carries a positive price, then a damages rule that includes that price will encourage more firms to negotiate earlier rather than treat infringement as a costless pathway to later bargaining. In turn, earlier agreements should reduce the share of licensing disputes that result in litigation and better align compensation with the Patent Act's requirement that damages be "adequate to compensate for infringement."[6] In addition to including that option value in the hypothetical negotiation, courts applying the *Georgia-Pacific* framework should also recognize that comparable licenses reached without equivalent timing flexibility might require adjustment before they can inform a reasonable royalty. In short, incorporating option value both fits within the existing framework and helps explain why a more accurate royalty can promote earlier contracting and less litigation.

I. Framework for the Determination of a Reasonable Royalty

Suppose the product I am making has been infringing your patent for the previous five years. At trial, my product has been found to infringe valid claims of your patent. What damages are you owed? Under section 284 of the Patent Act, damages for patent infringement must be "adequate to compensate for infringement, but in no event less than a reasonable royalty."[7] Courts typically determine a "reasonable royalty" through the application of the *Georgia-Pacific* factors, which frame the analysis in terms of a hypothetical negotiation between a willing licensor and a willing licensee at the time of first infringement.[8] A patent holder might receive damages in the form of lost

[4] Jeffrey Blumenfeld, *Should FRAND Excuse "Efficient Infringement"?*, 5 Criterion J. on Innovation 143 (2020).

[5] I address the application of the option value in a FRAND setting in a separate article, which is in progress as of July 2026. Whereas the FRAND commitment constrains the range of reasonable royalties and introduces additional considerations bearing on the licensor's obligations, the same economic logic that supports pricing the option to wait in the non-FRAND setting weighs in favor of accounting for the option value within the FRAND rate-setting process.

[6] 35 U.S.C. § 284.

[7] *Id.*

[8] The *Georgia-Pacific* framework is a multifactor analysis, with fifteen enumerated factors and no inherent guidance on the weighting of those factors. The fifteenth factor is itself the hypothetical negotiation, and courts and commentators have often interpreted the other factors as inputs into that negotiation. *See, e.g.*, J. Gregory Sidak, *Bargaining Power and Patent Damages*, 19 Stan. Tech. L. Rev. 1 (2015).

profits where those lost profits would exceed the magnitude of the reasonable royalty. In many instances, for example, if the hypothetical licensee does not practice the asserted patent or patents, the reasonable royalty is *both* the lower bound on damages *and* the default level of damages.

The *Georgia-Pacific* factors provide the standard framework for determining a reasonable royalty by reconstructing the hypothetical negotiation that a willing licensor and a willing licensee would have undertaken at the time infringement began.[9] Those factors consider, among other things, comparable licenses, the scope and duration of the license, the parties' commercial relationship, the profitability and advantages of the patented technology, the extent of the infringer's use, customary profit allocations, and expert testimony.[10] Most important for present purposes, Factor 15 asks what royalty these parties would actually have agreed to in that hypothetical bargain.[11] To the extent that patent infringement allows the user to delay payment until uncertainty about commercial success is resolved, such use confers a valuable real option on the prospective licensee and imposes a corresponding cost on the prospective licensor. A royalty that ignores that option understates the consideration that rational parties would have negotiated *ex ante* and therefore risks falling below the level required to compensate adequately for infringement.

A. Determination of the Bargaining Range

In the hypothetical negotiation, like any negotiation, the economic framework for analysis would be that of a bargaining problem in which the buyer's maximum willingness to pay would be determined by the expected value of the patented technology relative to its next-best (noninfringing) alternative. The seller's minimum willingness to accept would be determined by the opportunity cost of selling the license to the patented technology. The difference between the two represents the surplus generated by the beneficial transfer of the legal right from the seller to the buyer.[12] That is,

Courts have recognized that not all factors apply in a given negotiation, and that relevant considerations might exist that are not among the enumerated fourteen. For the history of patent damages before *Georgia-Pacific* and a critique of the framework, see Michael Risch, *(Un)Reasonable Royalties*, 98 B.U. L. Rev. 187 (2018).

[9] Georgia-Pacific Corp. v. United States Plywood Corp., 318 F. Supp. 1116, 1120 (S.D.N.Y. 1970) (Tenney, J.), *aff'd*, 446 F.2d 295 (2d Cir. 1971) (Feinberg, J.).

[10] *Id.*

[11] *Id.* ("15. The amount that a licensor (such as the patentee) and a licensee (such as the infringer) would have agreed upon (at the time the infringement began) if both had been reasonably and voluntarily trying to reach an agreement; that is, the amount which a prudent licensee—who desired, as a business proposition, to obtain a license to manufacture and sell a particular article embodying the patented invention—would have been willing to pay as a royalty and yet be able to make a reasonable profit and which amount would have been acceptable by a prudent patentee who was willing to grant a license.").

[12] Because the hypothetical negotiation occurs in a world in which infringement has already happened, it is plausible that a negative bargaining range would arise, particularly if the infringement is widespread

the hypothetical negotiation would effectuate a transfer of legal rights from a lower-valued user to a higher-valued user. As with any economic transaction between willing parties, both parties would be expected to gain from the transaction. The surplus would be divided between the two parties.

The option to infringe, as opposed to actually negotiating a license at the time of first infringement, arises from the nature of the remedy for patent infringement. The expected outcome of a negotiation at the time of first infringement is approximately equal to the remedy, which contemplates the outcome of that very negotiation as a reasonable royalty.[13] Note that any royalty within the bargaining range is reasonable, and the "expected outcome" is merely a point within that range.

B. Bargaining Over the Division of Surplus

Within the bargaining range, any division of surplus would produce an outcome that would be beneficial to both parties. Consequently, there are many royalties that would be reasonable outcomes. Determining an expected outcome of the bargaining game requires application of an economic theory of bargaining. For the purposes of this analysis, I consider that the parties engage in the alternating exchange of offers and counteroffers. In practice, this framework is somewhat consistent with observed bargaining behavior.[14] In the model presented below, I use this bargaining model to identify point royalties to analyze the welfare effects of including the option value within the reasonable royalty. That inquiry differs from asking whether a royalty that includes the option value is reasonable because it falls within the bargaining range. It necessarily follows that a point royalty identified by the bargaining model will lie within the range of reasonable royalties.

within a relatively competitive downstream market and the infringer is less efficient than its competitors. In such instances, the only reasonable royalty would be the patent holder's minimum willingness to accept.

[13] One difference is that, because the hypothetical negotiation would occur after a finding of patent validity and infringement, the royalty should exceed the royalty that would emerge from a negotiation in which either or both of those factors remained uncertain.

[14] Within the economics literature, this manner of bargaining is known as Rubinstein bargaining, and there exists a unique subgame-perfect Nash equilibrium to the Rubinstein bargaining game. A subgame-perfect Nash equilibrium is an expected outcome for a game in which (1) neither party can improve its payout by unilaterally deviating to a different strategy and (2) neither party makes a noncredible threat in the course of the game. *See* Ariel Rubinstein, *Perfect Equilibrium in a Bargaining Model*, 50 ECONOMETRICA 97 (1982).

II. The Hypothetical Negotiation That Does Not Include the Option Value of Infringement Is Not Adequate to Compensate the Patent Holder for the Infringement

At the time of first infringement, there might be significant uncertainty about the demand for the infringing product, the markets for complementary or substitute products, the validity of the patent or patents in question, and many other factors. At the time of the hypothetical negotiation, that uncertainty is present.[15]

Suppose a potential licensee expects to make, with probability 0.5, a profit of $100 per licensed unit produced and, with probability 0.5, $0 profit per licensed unit produced. Suppose further that the expected per-unit profit from a non-infringing alternative would be $20.[16] A risk-neutral licensee would then have a maximum willingness to pay of $30 per unit, which is equal to the difference between the expected profit of using the patented technology and the expected profit of using its next-best alternative at the time of infringement. That is, the expected profit of $50 (0.5 × $100 + 0.5 × $0 = $50), minus the value of the outside alternative of $20, is the patented technology's incremental value of $30.

Suppose further, for the sake of example, that the outside option to the patent holder is to develop a product practicing the patented technology that has an expected per-unit profit of $10. That $10 outside option would also serve as the minimum willingness to accept for the patent holder.

If the prospective licensee's maximum willingness to pay is $30 and the prospective licensor's minimum willingness to accept is $10, then the size of the surplus over which the parties will bargain is $20. The outcome of a bargaining game will be a function of the relative bargaining power of the two parties. If the relative bargaining power is such that 40 percent of the surplus would go to the licensor and 60 percent of the surplus would go to the licensee, then the expected outcome of the bargaining game at the time of first infringement would be for the licensee to receive $12 of the $20 surplus to pay a price of $18 (equal to the minimum willingness to accept of $10 plus

[15] This factor might also explain why it is often observed that licenses are executed for a duration that is less than the remaining life of the claimed invention. Why would a phone manufacturer only enter a 5-year license for a patent with 10 years remaining before its expiration? One economic factor that would increase the incentive to do so would be the concern that, in 5 years, the licensee is no longer manufacturing licensed devices. The licensee could similarly worry that, in 5 years, the licensed technologies could have been replaced by other technologies.

[16] When considering the incremental value of one technology compared with the next-best option, it is important to consider the profit generated by that next-best alternative as opposed to merely the revenue generated by that alternative.

the licensor's share of the surplus of $8) per unit for a license to implement the patented technology.

If the potential licensee is commercially successful and the potential licensor asserts its patent against the licensee by suing for patent infringement, the contemplated hypothetical negotiation used to calculate damages would rely on the information available to the parties at the time of first infringement.[17] Although the U.S. Court of Appeals for the Federal Circuit has allowed limited information unobservable at the time of first infringement to inform the parties' positions in the hypothetical negotiation, it has rejected the use of actual sales or profits.[18] So the success of the licensee could be immaterial to the determination of the reasonable royalty, and, given the factual parameters of this simple example, a reasonable royalty for the successful infringer would be $18.

What would a reasonable royalty be for the unsuccessful infringer? Given the parameters discussed above, it would also be $18. That is, the hypothetical negotiation at the time of first infringement with the commercially unsuccessful infringer would use the same factual inputs as the negotiation with the commercially successful infringer. However, the probability of ever receiving such a royalty is minimal. With an unsuccessful product, the patent holder might never actually observe that the infringement has occurred. Similarly, the company that developed the infringing, but commercially unsuccessful, product could cease operations. Simply put, the expected judgment, or at least the one that the patent holder could expect to collect, might well be less than the costs of litigation. Patent litigation is expensive and time consuming, and it cannot be pursued against all potential infringers at once. The patent holder might have little incentive to assert its patents against the unsuccessful infringer. Moreover, the unsuccessful infringer could easily be judgment proof.

For the sake of example, assume that the patent holder cannot extract a positive royalty payment from the unsuccessful infringer.[19] The expected value of patent licenses would then be $9, equal to the $18 royalty times the 0.5 probability that the infringer is commercially successful, before discounting to present value. Nine dollars is less than the $10 minimum willingness to

[17] J. Gregory Sidak, *How Relevant Is Justice Cardozo's "Book of Wisdom" to Patent Damages?*, 17 Colum. Sci. & Tech. L. Rev. 246, 280 (2015) ("[T]he Federal Circuit has consistently rejected reliance on post-infringement information that did not assist the finder of fact in inferring the parties' negotiating positions at the time of the hypothetical negotiation. For example, the Federal Circuit has rejected reliance on information about the infringer's actual sales or actual profits when that information differs from what the parties would have projected at the time of their hypothetical negotiation.").

[18] *Id.* (citing Radio Steel & Mfg. Co. v. MTD Prods., Inc, 788 F.2d 1554, 1557 (Fed. Cir. 1986) (Friedman, J.); *see also* Risch, *(Un)Reasonable Royalties*, *supra* note 8, at 224–26.

[19] If the patent holder can collect a royalty payment greater than zero but less than the expected royalty at the time of first infringement, then the magnitude of the option value might decrease, but the under-compensation of the patent holder will remain.

accept that the patent holder would have at the time of first infringement. It cannot be the case that such a royalty would be "adequate to compensate for infringement" as required by section 284 of the Patent Act.[20] In that scenario, the patent holder would prefer to exercise its outside option to licensing, and a negotiation at the time of first infringement would never result in a mutually beneficial transaction.

What would happen if the parties were to agree that the licensee could observe the success or failure of the licensed product before paying $18 per unit for the license? That is, what would happen if the parties bargained over not only the license, but also the real option to execute the license only in the event of a commercially successful product? With probability 0.5, the licensee will produce a successful product, which will have an incremental value of $80 per unit. Subtracting the $18 per-unit royalty, the licensee would observe profits of $62 per unit. With probability 0.5, the licensee produces an unsuccessful product and is bankrupted, paying no royalty. The expected value of the option to purchase in the license at the price that would have occurred in the hypothetical negotiation (but only after observing the success of the product) is $31 per unit (or 0.5 × $62). To be purposefully conservative, assume that the licensee's willingness to pay for that option would be $14.[21]

For simplicity, assume that a firm produces one licensed unit. What would be the cost of the option to the licensor? It would be sacrificing $18 in royalties today to receive, with probability 0.5, $18 tomorrow if the licensed technology is commercially successful; and $0 otherwise. With a 10-percent discount rate on the $9 per-unit expected royalty rate, the discounted value of that payment would then be $8.10. As the option reduces the present value of the payment to the licensor by $9.90, the licensor would not accept an offer for the option of less than $9.90.

The option itself could create another potential bargaining game. If the parties bargained over the option, the expected outcome based on the division of surplus described above would be about $11.50. That is, the licensee would pay $11.50 at the time of first infringement for the option to pay $18 in the event of a successful product. The total expected payment would then be $20.50 (that is, $11.50 + [0.5 × $18]). Thus, the hypothetical negotiation at the time of first infringement, resulting in a payment of $18 for the successful infringer, would be under-compensatory for the patent licensor relative to an

[20] 35 U.S.C. § 284.

[21] There are different types of options-valuation models that require or incorporate different inputs and would be best applied across a variety of settings. In some instances, the maximum willingness to pay for the option could be as great as $31. For the purposes of this example, I consider a much lower option value. Although financial options will typically have a single observable value, real options values might be more idiosyncratic at the firm level. *See generally* Avinash K. Dixit & Robert S. Pindyck, Investment Under Uncertainty (Princeton Univ. Press 1994); Richard A. Brealey, Stewart C. Meyers & Franklin Allen, Principles of Corporate Finance 600 (McGraw-Hill Irwin 9th ed. 2008). In Part V, the analysis will focus on a generic option value rather than the application of a specific model.

actual negotiation for the option to delay licensing plus a probabilistic future royalty payment, which would result in a payment of $20.50.

In that simple setting, the patent license at the time of first infringement would have an expected royalty of $18. The "flexible ticket" version of the patent license would have a higher price of $20.50; however, the buyer would maintain the flexibility to avoid the higher payment in the event of an unsuccessful product launch.[22]

Regardless of the outcome of the bargain, or the option-value model used, the simple motivating fact is that if the parties negotiated to generate the right to buy a product in the future at a price determined today, that option would have positive value to the licensee and would come at a positive cost to the licensor.

Consider the scenario where two infringers are engaged in a race to develop a new product. It is plausible that the winner of the race might observe high profits while the loser experiences only nonrecoverable losses. A patent owner might assert its intellectual property rights against the commercially successful infringer. In that scenario, as described above, the damages "adequate to compensate for infringement" from the successful firm would be a royalty of $18 and an option payment of $11.50. However, for the same reasons that the patent owner might not be able to obtain a royalty payment from the unsuccessful infringer, such as it being judgment proof or simply that the direct costs and opportunity costs of a suit exceed the expected damages, it also would be unlikely to obtain the option value through post-infringement enforcement. Consequently, the expected reasonable-royalty damages might fall below the level of compensation adequate to compensate for infringement even after the inclusion of the option value.

There are multiple methodologies for estimating the value of a real option. The choice of methodologies and the time horizon over which the option should be valued are ultimately a fact-specific inquiry. The proper time frame and option-valuation methodology could be unique to the licensor-licensee pairing.

In most cases, the option value takes the form of a fraction of the expected value of the royalty if negotiated at the time of first infringement. If the option value is x multiplied by that royalty, it can take the form of a

[22] A reader might pause here to consider that the flexible airline ticket offers a full refund if canceled. However, when booking a flight, there are often multiple tiers of flexibility. An inexpensive ticket might not offer changes or refunds. An intermediate ticket might allow changes, with or without a fee, but not a refund. A most expensive ticket might offer a full refund. In some instances, the purchaser is offered the option of paying an additional premium, $150 for American Airlines as of the writing of this article, to have the option of a refund in the original form of payment rather than a travel credit. In this article, I discuss a setting in which a licensee would theoretically pay the option value at the time of first infringement, and I compare it with the situation in which the licensor is not compensated for the option value. A third possibility would be a more flexible option in which the upfront option payment is refundable. That possibility would likely require some premium on the option payment.

lump-sum payment, a running per-unit royalty, or a running royalty rate. The option value can easily match the form of royalty payment that reflects the bargaining parties' relative risk preferences. If the option were paid at the time of first infringement and the royalty were paid at a later time when the option is exercised, the total payment could resemble a two-part tariff with an up-front payment, or access price, for the option and a running royalty, or usage price, for the practice of the patented innovation.

Similarly, different preferences over risks could easily lead to more creative options contracts. A licensor-licensee pairing could adjust the relative option price upward or downward and make an offsetting adjustment to the royalty paid at a later date. In that sense, the option-plus-royalty framework is a more general characterization of the licensing agreement.

III. Real Options

Contemporary models of real options, or the value of commercial flexibility, use approaches derived from option-valuation models that financial economists first developed in the early 1970s.[23] Financial options are well-known instruments that, for example, can allow an option holder to purchase shares of a corporation at a certain price on a certain date. Although a holder might or might not eventually exercise those options, they are valuable assets before their maturity date. The foremost such financial option-valuation method, known as the Black-Scholes model, earned professors Robert Merton and Myron Scholes the 1997 Nobel Prize in economics.[24]

A. Literature on Real Options

In the 1990s, economists adapted the Black-Scholes model and other financial option-valuation methodologies to analyze "real options," which describe the options to make real-world business decisions as opposed to purely financial options. One application of the real options analyses was the pricing of mandatory competitor access to telecommunications networks at regulated

[23] *See generally* Dixit & Pindyck, Investment Under Uncertainty, *supra* note 21; Fisher Black & Myron Scholes, *The Pricing of Options and Corporate Liabilities*, 81 J. Pol. Econ. 637 (1973). In the private sector, investors routinely value and trade stock options using financial option pricing methodologies such as the Black-Scholes model. *See, e.g.*, Zvi Bodie, Alex Kane & Alan J. Marcus, Investments 655–82 (Irwin McGraw-Hill 4th ed. 1999).

[24] *See* Brealey, Meyers & Allen, Principles of Corporate Finance, *supra* note 21, at 600; Press Release, Nobel Prize, The Prize in Economic Sciences 1997 (Oct. 14, 1997), http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1997/press.html. Fisher Black died before the 1997 Nobel Prize was awarded.

prices.[25] The adaptations served primarily to incorporate differences in the rules that structure the exercise of financial and real options, respectively.[26]

In access pricing, telecommunications regulators have considered real options as an input to the process of determining regulated access to network inputs.[27] Scholarly articles have considered the role of real options in determining lost-profits damages in patent-infringement matters,[28] in trade secret misappropriation matters,[29] and in pricing access to railways[30] and data.[31]

Jerry Hausman, Gregory Leonard, and Gregory Sidak criticized the Federal Circuit's 1999 decision in *Grain Processing Corp. v. American Maize-Products Co.*[32] Specifically, they observed that the decision allowed for the calculation of lost-profits damages to consider the use of a noninfringing alternative that was not used in practice.[33] That methodology for calculating lost profits grants the infringer a valuable option that reduces the lost-profits damages.[34] Although Hausman, Leonard, and Sidak introduced a framework for reasonable-royalty damages and used a reasonable royalty as a

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[25] *See, e.g.*, Dixit & Pindyck, Investment Under Uncertainty, *supra* note 21; Jerry Hausman, *The Effect of Sunk Costs in Telecommunications Regulation*, *in* The New Investment Theory of Real Options and its Implication for Telecommunications Economics 191 (Springer U.S. 1999); Brealey, Meyers & Allen, Principles of Corporate Finance, *supra* note 21, at 589–637; Jerry A. Hausman & J. Gregory Sidak, *A Consumer-Welfare Approach to the Mandatory Unbundling of Telecommunications Networks*, 109 Yale L.J. 417, 458–59 (1999); Robert S. Pindyck, Mandatory Unbundling and Irreversible Investment in Telecom Networks (MIT Sloan Sch. of Mgmt., Working Paper No. 4452-03, 2003).

[26] *See generally* Dixit & Pindyck, Investment Under Uncertainty, *supra* note 21.

[27] *See, e.g.*, UK Off. Commc'ns [Ofcom], Ofcom's Approach to Risk in the Assessment of the Cost of Capital (2005), http://stakeholders.ofcom.org.uk/binaries/consultations/cost_capital2/statement/final.pdf; UK Off. Gas & Elec. Mkts. (Ofgem), Decision of Strategy for the Next Gas Distribution Price Control (2011), https://www.ofgem.gov.uk/ofgem-publications/48258/gd1decision.pdf; UK Off. Gas & Elec. Mkts. (Ofgem), Real Options and Investment Decision Making 13 (2012), https://www.ofgem.gov.uk/ofgem-publications/48227/realoptionsinvestmentdecisionmaking.pdf; Australian Energy Regul. (AER), Regulatory Investment Test for Transmission 4 (2010), https://www.aer.gov.au/system/files/Final%20RIT-T%20-%2029%20June%202010.pdf. The AER enforces rules established by the Australian Energy Market Commission; *see also* Australian Energy Regul., Regulatory Investment Test for Transmission and Regulatory Investment Test for Transmission Application Guidelines 12–13 (2010), http://www.aer.gov.au/system/files/RIT-T%20Final%20decision%20-%2029%20June%202010.pdf ("[The AER] leaves it open for the [Transmission Network Service Provider (TNSP)] to estimate additional option value which is not already captured in other classes of market benefit."); New Zealand Elec. Comm'n, Grid Investment Test ¶ 61, at 14 (2004), https://www.ea.govt.nz/dmsdocument/627/.

[28] *See* Jerry Hausman & Gregory K. Leonard. *Real Options and Patent Damages: The Legal Treatment of Non-Infringing Alternatives, and Incentives to Innovate*, 4 J. Econ. Surveys 20 493 (2006); Jerry Hausman, Gregory K. Leonard & J. Gregory Sidak, *Patent Damages and Real Options: How Judicial Characterization of Noninfringing Alternatives Reduces Incentives to Innovate*, 22 Berkeley Tech. L.J. 825 (2007).

[29] *See* Michael Risch, *Why Do We Have Trade Secrets?*, 11 Marq. Intell. Prop. L. Rev. 1 (2007); J. Gregory Sidak, Trade Secrets and the Option Value of Involuntary Exchange (Criterion Econ., Working Paper, 2008), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=577244 (2008).

[30] *See* Jerry Hausman & Stewart Myers, *Regulating the United States Railroads: The Effects of Sunk Costs and Asymmetric Risk*, 22 J. Regul. Econ. 287, 292–94 (2002).

[31] *See* Jordan Barry & D. Daniel Sokol, *Data Valuation and Law*, 96 S. Cal. L. Rev. 1545 (2022).

[32] Hausman, Leonard & Sidak, *Patent Damages and Real Options: How Judicial Characterization of Noninfringing Alternatives Reduces Incentives to Innovate*, *supra* note 28, at 826 (discussing Grain Processing Corp. v. Am. Maize Prods. Co., 185 F.3d 1341 (Fed. Cir. 1999) (Rader, J.)).

[33] *Id.* at 828–29.

[34] *Id.* at 842–43.

part of their calculation of the reduction in damages, they did not analyze the value of the option granted through the calculation of reasonable royalties, and they did not present potential methodologies for including that option value within the damages calculation.[35] I address the option value created by the implementation of the reasonable royalty calculation. One could characterize Hausman, Leonard, and Sidak as stating that the Federal Circuit's decision is incorrect because it created a free option for the infringer. My analysis could be characterized as stating that the decision that created an option is not necessarily right or wrong, but instead that if such an option was created, then that option should be valued and included in the hypothetical negotiation. Simply put, if the decision, or the widespread use of the *Georgia-Pacific* framework, created an option, then there is no reason to assume that option is free.

Although much of the literature or applications of real options valuation discusses option valuation generally, some economists do implement specific methodologies. For example, Avinash Dixit's and Robert Pindyck's 1994 book on real options presents a wide variety of applications for which methods derived from the Black-Scholes model can be used to determine option values.[36] Pindyck and Hausman each utilize this approach in different applications.[37] In another instance, Hausman and Stewart Myers utilize Monte Carlo simulations to estimate a real option value.[38] Some regulators that allowed for the estimation of option values in regulated access used binomial trees as the method of option valuation.[39]

Since the 1970s, additional progress has been made in the analysis of financial options, such as the incorporation of stochastic volatility into the modeling of options.[40] As the facts of a given case demand it, such insights could carry over to the analysis of real options.

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[35] *Id.* at 831–32, 845–46.

[36] Dixit & Pindyck, Investment Under Uncertainty, *supra* note 21.

[37] *See, e.g.*, Jerry Hausman, *The Effect of Sunk Costs in Telecommunications Regulation*, *supra* note 25, at 191–204; Pindyck, Mandatory Unbundling and Irreversible Investment in Telecom Networks, *supra* note 25.

[38] *See* Hausman & Myers, *Regulating the United States Railroads: The Effects of Sunk Costs and Asymmetric Risk*, *supra* note 30, at 292–94.

[39] *See, e.g.*, UK Off. Gas & Elec. Mkts. (Ofgem), Real Options and Investment Decision Making, *supra* note 27.

[40] *See, e.g.*, Steven L. Heston, *A Closed-Form Solution for Options with Stochastic Volatility with Applications to Bond and Currency Options*, 6 Rev. Fin. Stud. 327 (1993); Mark Broadie & Özgür Kaya, *Exact Simulation of Stochastic Volatility and Other Affine Jump Diffusion Processes*, 54 Operations Rsch. 217 (2006); Roger Lord, Remmert Koekkoek & Dick Van Dijk, *A Comparison of Biased Simulation Schemes for Stochastic Volatility Models*, 10 Quantitative Fin. 177 (2010).

B. Real Options Are Beneficial to the Recipient and Costly to the Provider Even in Seemingly Established Industries

As in the example presented in the Introduction to this article, real options are generally beneficial to the recipient and costly to the provider. The licensor selling the real option sacrifices expected future revenue, and the licensee increases its expected returns from the project that implements the licensed technologies. Clearly there would be an interest in optional licensing in new, evolving industries where market outcomes are highly uncertain. However, even in seemingly established industries, there might exist significant uncertainty at the firm level.

An infringer can observe the cost of its investment in a licensing payment, but it cannot definitively observe the future value of that investment. Uncertainty about sales, about consumer preferences, about demand for different features, or even about the deployment of complementary products all will influence the value of a license to the infringer. For example, if the buildout of infrastructure that supports the licensed product is slower than expected, the consumer's willingness to pay for the downstream product might be lower than expected, decreasing both the infringer's profitability on those items and its willingness to pay for a license. Waiting to make that investment increases the value of the project supported by that investment. The unlicensed infringer has enriched itself by the value of the commercial flexibility it gains by forgoing or delaying any royalty payments.

IV. The Hypothetical Negotiation Should Consider the Real Option

The simplest and most convincing argument for the inclusion of a real option value as part of the hypothetical negotiation is that its exclusion yields a royalty that is not "adequate to compensate for infringement" as required by section 284 of the Patent Act.[41] As demonstrated in the simple example in Part II, it is quite possible that in the absence of the option value in the hypothetical negotiation, the expected royalty payment could easily fall below the patent holder's minimum willingness to accept at the time of first infringement.

In addition, in the absence of the option value, the infringer has no incentive to initiate licensing. The damages the infringer would be asked to pay in the hypothetical negotiation would be the same in expected value as the royalties that would be owed in an actual negotiation.[42] There would be little

[41] 35 U.S.C. § 284.

[42] One small difference would be that damages are typically calculated assuming findings of infringement and validity. The actual negotiation could include some discount for the probability that an asserted

to no incentive for the infringer to engage in costly negotiations that would yield no incremental benefit relative to waiting until the patents are asserted against it. In that scenario, relative to a world in which waiting might still be beneficial but not free, the share of licenses that results from litigation would likely also increase.

Gary Becker famously described his inspiration behind the economic analysis of crime and punishment as based on the cost of parking in a garage versus parking on the street and receiving a parking ticket with some probability.[43] Patent infringement is not an exact analogy but is nevertheless similar. Whereas Becker contemplated knowingly parking illegally and the probability of receiving a fine that exceeded the cost of parking legally, imagine the situation where the fine for not putting money in a parking meter is equal to the amount of money that I would have needed to put into the meter. Assuming that I have no psychological cost associated with not paying for parking, I have no incentive to search for information indicating the payment necessary to park in a given spot and to pay for parking. In many instances, parking could involve locating a pay station, making a mobile or credit card payment, and returning a parking receipt to display on the dash of the parked vehicle. If a fine is only equal to the amount I would pay, I have no economic incentive to incur the costly search to enable my paying for the parking spot. Similarly, if the hypothetical negotiation would produce the same royalty as an actual negotiation, what incentive does the infringer have to incur the costs necessary to engage in licensing negotiations? I am not necessarily knowingly and willfully parking illegally. My location might well offer free parking. But if the price of parking is the same whether I incur the costly search to discover that price or simply wait to let the city identify that price, even if enforcement is 100-percent successful, I will still choose not to pay for my parking. Similarly, the infringer need not be willfully infringing if the system of patent enforcement encourages such willful ignorance.

In an alternative scenario, I might compare (1) paying a $30 ticket with some probability less than one with (2) paying $20 for a garage with certainty. Or I might need to compare the benefits of long-term and short-term parking before a business trip with an uncertain return date. Regardless of the scenario, I would make a business decision based on my risk preferences, available information, prior beliefs, and other factors. Similarly, the decision to make, identify, and license potentially infringed patents is a business decision that will depend on firm-specific observable and unobservable factors.

patent is not in fact valid and enforceable. Of course, this would be an additional source of uncertainty which will generate additional option value for the infringer. *See* Hausman, Leonard & Sidak, *Patent Damages and Real Options: How Judicial Characterization of Noninfringing Alternatives Reduces Incentives to Innovate*, *supra* note 28, at 826–27, 842–43.

[43] Gary Becker, Nobel Lecture: The Economic Way of Looking at Life (Dec. 9, 1992), https://www.nobelprize.org/uploads/2018/06/becker-lecture.pdf.

The current application of the *Georgia-Pacific* factors greatly tips the scales in favor of waiting.

The ability to wait is valuable for the infringer. But it is not uniformly valuable. Charging a price of $0 for the ability to wait and forcing the patent holder, who cannot necessarily observe the value to an infringer of waiting, to determine the schedule by which patent rights are enforced or asserted will result in an inefficient allocation of the option to wait.

Just as prices serve as signals of value for goods and services, prices also serve as signals of value for options, real and financial. A legal regime that excludes the option value at the time of first infringement effectively sets the price of the option to wait at $0 and fully empowers the patent holder, the party with the least information about the infringer-specific value of waiting, to determine the time at which that option expires. The optimal allocation of options will be that the parties that have the greatest to gain by waiting will also have the highest willingness to pay for the right to wait and will purchase that right. Parties for whom the ability to wait is less valuable will be less willing to pay for that right and will be more likely to enter into contracts sooner rather than later.

The implementation of the hypothetical negotiation without option values obstructs the efficient allocation of risk in the markets for patented innovations. The ability to wait is not transferable except perhaps through the market for corporate control.[44] The decision of the patent holder to assert its patents and thus end the option period is made without the ability to observe for whom the value of waiting is greatest. Without any regulation on the market for waiting, one would expect an efficient allocation to obtain regardless, but the approach to patent damages granting a free option prevents that efficient allocation. Effectively, the price of the option to wait is set by rule at $0. In most circumstances, a firm receiving a product for a price of $0 will not negotiate to pay a greater price for that product.

Finally, if bargained over at the time of first infringement, the option to wait will have a positive price. The option to wait will have a value to most licensees that exceeds the cost of providing that option for most licensors. Thus, there is a positive surplus to be gained by enabling transactions over the timing of payments. If the goal of the hypothetical negotiation at the time of first infringement is to recreate the negotiation between the licensor and infringer in the but-for world, then there should be compensation in exchange for valuable consideration in the form of an option.

[44] When control of a corporation changes hands, the option to infringe will transfer as well. *See* J. Gregory Sidak, *Is Patent Holdup a Hoax?*, 3 Criterion J. on Innovation 401, 461–64 (2018); J. Gregory Sidak, *Monopoly, Innovation, and Due Process:* FTC v. Qualcomm *and the Imperative to Destroy*, 6 Criterion J. on Innovation 1, 743 (2020).

Because there should be compensation in exchange for the option in the hypothetical negotiation, there are two direct implications for the application of the *Georgia-Pacific* factors. First, the application of Factor 15 should include the price that a willing licensee would pay to a willing licensor at the time of first infringement for payments that would start *n* years (or months) after the hypothetical negotiation. Second, any analysis of comparable agreements might require an upward adjustment for that option value. Simply put, using as comparable a license absent that adjustment is incorrect and might bias the analysis.

V. The Inclusion of the Real Option Improves Welfare

In this Part, I consider the possible welfare effects of the inclusion of the real option. I model and simulate a bilateral bargaining game between a single potential licensee and a patent holder both with and without the inclusion of the option value in the hypothetical negotiation. The model and results presented are not intended to be a calibration of a specific real-world negotiation, which would require the observation of party-specific inputs. Rather, my analysis offers insight into the dynamics of the negotiation in the presence of the option value.

Whereas the inclusion of the option value does increase the total expected payment for more profitable infringers, it also increases the speed with which the infringer initiates negotiations over a license. Giving the infringer more control over the timing of the negotiation has the effect of both decreasing the borrowing costs of the infringer and allowing the infringer to obtain a greater share of the surplus generated by the patented technologies and the surplus generated by the option itself. This effect is particularly beneficial when the infringer faces a more aggressive patent holder.

A. The Bilateral Bargaining Game

To introduce the bargaining framework and to examine the role of real options in the negotiations between the patent holder and a downstream manufacturer, consider a simple interaction between the patent holder and a monopolist that produces a licensed product.

Let demand for the potential licensee's patent-practicing product be given by

$$p = a - bq. \tag{1}$$

The licensee produces that product at constant average and marginal cost *c*. The profit-maximizing price is given by

$$p^* = \frac{a+c}{a}. \tag{2}$$

The profit maximizing quantity is then

$$q^* = \frac{a-c}{2b}. \tag{3}$$

The monopolist's profits would then be

$$\pi = \frac{(a-c)^2}{4b}. \tag{4}$$

Suppose the potentially licensed patented technology increases profits by $x + f$, and the opportunity cost of licensing to the patent holder is f. Then the potential surplus from licensing the patented technology is x.

When either party initiates bargaining, the two parties engage in alternating-offers bargaining. The party that initiates the bargaining makes the first offer. If d_1 is the discount rate of the first party to make an offer and d_2 is the discount rate of the second party to make the offer, the subgame perfect equilibrium of the bargaining game yields the division of surplus such that the player that makes the first offer receives the following share of the surplus:

$$\frac{1-d_2}{1-d_1 d_2}. \tag{5}$$

The discount rate of the licensor is fixed in the model, but the discount rate of the manufacturer is subject to a random shock that is correlated with but not necessarily equal to the shock to its borrowing costs.

If negotiations occur in period t, then the option value is calculated using the binomial options pricing model based on an option length equal to t.[45] Bargaining occurs over the price of the option with the same division of surplus as is given above in the negotiation over the value of the patented innovation.

Each period of the model begins with the observation of the random variables. Before either party can initiate bargaining, market shocks are revealed. If the manufacturer is forced to exit the market, no further negotiations take place, and the royalty paid is $0. The game ends at that point.

Next, the licensor initiates negotiations with a probability determined by its aggressiveness factor. If the licensor initiates negotiations, both the

[45] Results are robust to various other option valuation approaches, including simply calculating the option value as a fixed multiplier of the royalty payment. Simply put, the dynamics of this illustrative example are driven by the fact that in the presence of the option payment, the licensee's incentives to wait are mitigated. Those licensees for whom waiting is valuable will choose to wait, while those with a smaller expected benefit to waiting will enter negotiations earlier.

royalty and option value are negotiated, and the licensee pays the licensor the sum of the two measures.

If the potential licensor does not exit the market and the patent holder does not initiate bargaining, the licensee is given the decision to initiate bargaining or to wait until the next period. If negotiations occur, both the royalty and option value are negotiated, and the licensee pays the licensor the sum of the two measures. If no negotiation occurs, then the game moves to the next period.

Because this analysis is primarily concerned with the measure of the royalty, the game ends when a license is reached. If no license is reached and the manufacturer does not exit the industry, the game continues.[46]

The decision of the manufacturer whether to negotiate in a given period is determined by the expected value of an agreement in that period relative to the expected value of waiting. If, and only if, the expected value of negotiating a license exceeds the expected value of waiting will the manufacturer initiate the bargaining process.

The game is simulated 25,000 times with the inclusion or exclusion of the option value in the hypothetical negotiation randomly determined with equal probability. Results are compared to identify the effects of the inclusion of the option value on bargain outcomes.

To test the effect of different patent rules over different possible parameterizations of the model, several sources of randomness are added to the model. Two methods are used to introduce market risk to the monopolist. In the first instance, with probability z, the manufacturer exits the market in any given period. In either period, the manufacturer observes its demand shock or forced exit before deciding whether to engage in licensing. In the second instance, demand shocks are incorporated into the model. The demand intercept evolves such that

$$a_t = a_{t-1} + \varepsilon, \tag{6}$$

where ε is a random shock distributed uniformly with a magnitude depending on the value of a. As a evolves over time, profits will rise or fall. If a falls significantly, it can force the manufacturer to exit the market. A firm that anticipates a higher probability of future exit will be less likely to choose to initiate bargaining over a license to the patented technology.

The firm is also able to observe its borrowing costs, which are given by the long-term average borrowing costs plus a random shock. In periods where the borrowing costs are lower, the manufacturer will be more likely to

[46] Although the game could continue indefinitely, as it extends longer, the expected option value will increase, increasing the incentive for the manufacturer to engage in licensing negotiations.

engage in bargaining, anticipating that future observations of borrowing cost will likely exceed the observed costs in this period.

The model assigns to the licensor an aggressiveness factor $y \in (0,1)$ such that with probability y it will assert its patents in a given period. For purposes of analyzing how the licensor's aggressiveness influences the potential licensee's behavior, the aggressiveness of the licensor is determined at the beginning of any negotiation and remains constant throughout that potential negotiation.

B. Results

Table 1 presents the results of the bargaining game both with and without the option included in the reasonable royalty for the simplest version model, which is based on a constant, exogenous probability of exit and excludes the possible assertion by the patent holder. The value of the patented invention is normalized to 1.

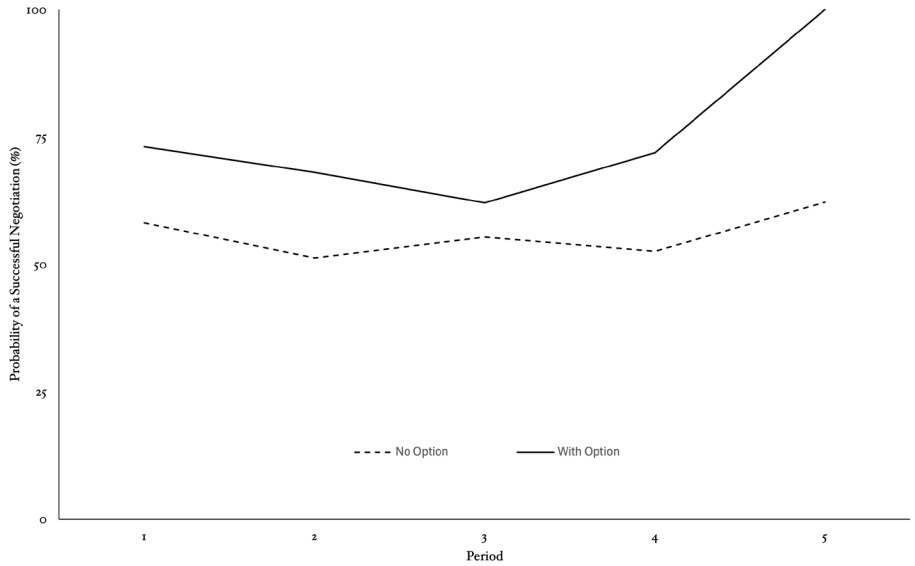
Table 1. Simulated Payments and Agreement Rates

With Option Value	Average Payment	Probability of an Agreement in Any Period of the Game (%)	Share of Negotiations That Result in an Agreement (%)	Average Period in Which an Agreement Occurs
No	0.276	90.66	55.98	1.71
Yes	0.309	94.14	71.96	1.36

Note: These results are for 25,000 simulations of the negotiation game. While the results are similar across different simulations, if repeated, similar (but not identical) results would be expected.

As Table 1 indicates, the expected payment is higher when the option value is included in the hypothetical negotiation. In this instance, the average payment with the option exceeds the average payment without the option by about 12 percent (that is, 0.309 ÷ 0.276 = 1.120). With the presence of the option, it is more likely that the manufacturer chooses to negotiate a license in each observed period. It is also more likely that an agreement is reached over the course of the game. The average period in which an agreement is observed is earlier with the inclusion of the option. Only those negotiations that do not reach an agreement in Period 1 will continue to Period 2. In each period, the probability of an agreement is somewhat consistent across cases. Figure 1 shows the probability that a successful negotiation is observed if the game reaches a specific period.

Figure 1. Probability of Agreement by Period of Negotiation



As Figure 1 indicates, when the option is included in the payment, an agreement becomes more likely. That is, the manufacturer becomes more likely to initiate the bargaining process.

The manufacturer will have observed values of borrowing costs and bargaining power in Period *t* and expectations about borrowing costs and the risk of failure in the future. If the expectations about the future are not state-dependent,[47] then the manufacturer's decision will be a function of the observed borrowing costs and bargaining power, which are correlated by design. The manufacturer essentially decides whether to agree to a payment determined by the parameters of the model today or to wait for new parameters to be realized in the next period. For given levels of an observed variable, there will be a marginal manufacturer that is indifferent between negotiating today and waiting to consider negotiating in the next period. All manufacturers with lower borrowing costs or more bargaining power than the marginal manufacturer will choose to negotiate. All else equal, manufacturers with higher borrowing costs or less bargaining power than the marginal manufacturer will choose to wait. A convenient way to consider the effects of the option value's inclusion in the payment or changes in the parameters of the model is to consider how the location of the marginal manufacturer would move within the parameter space.

[47] Expectations are state-dependent if the expected value of a random variable in the next period is a function of the values of variables in the current period. In this simplest version of the model, expectations are not state-dependent.

Similarly, there will be levels of licensor aggressiveness, given borrowing costs and the probability of future exit, and levels of the probability of future exit, given borrowing costs and licensor aggressiveness, where a manufacturer might be indifferent between licensing and waiting. The inclusion of the option value serves to move the indifference values such that licensing becomes likely over a wider range of parameter values.

One factor driving the higher payment in the presence of the option value is that it encourages the manufacturer to initiate licensing negotiations earlier in the game. Negotiating earlier in the game increases the probability that there will be an agreement before a potential exit from the market. Table 2 shows the values in Table 1 if the observations are limited to those in which a successful negotiation takes place.

Table 2. Simulated Payments—Only Including Agreements

With Option Value	Average Payment	Average Period in Which an Agreement Occurs
No	0.304	1.71
Yes	0.328	1.36

As indicated in Table 2, the option value's inclusion increases the expected royalty rate, but now by a smaller amount. In this instance, the average payment with the option exceeds the average payment without the option by approximately 7.9 percent (that is, 0.328 ÷ 0.304 = 1.079). So when negotiations take place, the option value's effect on the royalty is smaller than the initial comparison of payments would indicate.

In addition, the payment will vary depending on the period in which an agreement is reached. Table 3 shows the average payment from licensee-initiated negotiations by the period in which the negotiation takes place.

Table 3. Average Payment by Period of Agreement

With Option Value	Period 1	Period 2	Period 3	Period 4
No	0.305	0.304	0.304	0.304
Yes	0.326	0.333	0.345	0.361

As Table 3 indicates, the difference in the average payment from negotiated agreements with and without the option is less than the simple differences in averages might indicate. With the option in place, more negotiations

take place, and fewer bankruptcies are observed. Two factors drive the differences in payments. First, in Period 2 or later, the option has a positive value. Including the bargained-for price of the option in the payment will necessarily increase the total payment. Second, as demonstrated in Period 1, the inclusion of the option value will affect the manufacturer's decision of whether to negotiate. Because Period 1 is the first period in which negotiations can occur, the option value is zero and the payment for any given set of parameters is the same in both cases. As a result, the difference in expected payments is a function of how the presence of the option value moves the marginal manufacturer. Because the option is an increasing function of the period in which an agreement is reached, and the expected payment without the option is constant, as indicated in Table 3, the marginal manufacturer in the absence of the option will prefer to negotiate in Period 1, and the new marginal manufacturer will have higher borrowing costs or less bargaining power.

Consider the rate at which negotiations occur in Period 1 as presented in Figure 1. In the absence of the option, 58.2 percent of all simulations observed an agreement in Period 1. With the option included, 73.1 percent of all simulations observed an agreement in Period 1. The inclusion of the option increased the probability of an agreement by 14.9 percentage points, or by 25.6 percent (that is, 73.1 percent ÷ 58.2 percent = 1.256). Note that for any given manufacturer, the option value in Period 1 is zero, and the royalty payment is identical with or without the option. So the presence of the option has the effect of encouraging more contract formation without increasing the royalty that would be paid in those instances.

Another result of note is that, upon including the possibility that the patent holder can choose to assert its patents, firms with lower borrowing costs and firms that face more aggressive patent holders are both much more likely to enter into negotiations than would be firms with higher borrowing costs or firms negotiating against less aggressive patent holders regardless of the inclusion of the option value. In the presence of the option, both of those patterns are stronger.

Finally, when modeling the probability of bankruptcy based on market shocks, in the presence of the option, more profitable firms are much more likely to initiate negotiations. Because the probability of bankruptcy is lower, the value of waiting is less, and if the more profitable firm observes a period of low borrowing costs, it is more likely to initiate negotiations.

This example is merely a simulation of a stylized setting. However, it offers insight into the dynamics that characterize the decision-making process for potential licensors and licensees. Because the presence of the option value increases the parameter space over which a manufacturer will choose to engage in licensing negotiations, the results follow similar patterns

for different approaches to calculating the option value, and for different parameterizations of the simulation.

VI. Implications for the Economic Coherence of Judicial Determination of Reasonable Royalties

Adequate compensation for infringement requires the inclusion of the option value in the determination of reasonable royalties for patent infringement. Regardless of the static welfare effects of the inclusion of the option value, the traditional hypothetical negotiation is under-compensatory to the patent holder. The inclusion of the option value would appear to have offsetting welfare effects. In the short run, the inclusion of the option value would be expected to increase expected royalty rates, increasing downstream prices. However, adequate compensation for patent infringement would allow the patent holder to receive just compensation for its patented innovation, increasing expected returns to research and development and, in turn, increasing expected investment in research and development.

The relative magnitude of the two effects would determine the overall welfare effect of including the option value in the reasonable royalty calculation. However, the static price effect is likely to be smaller than the size of the option value. In the presence of the option value, expected total royalties and per-unit royalty rates often increase as the infringer waits to obtain a license. Consequently, the inclusion of the option value will have the effect of increasing the potential licensee's incentives to obtain a license at an earlier time. In the presence of the option value as a part of the reasonable royalty, more negotiations are observed at the beginning period of the bargaining game. Moreover, because the decision to engage in licensing negotiations is endogenous, the infringer will time the negotiation for periods when borrowing costs are lower and the expected division of the surplus favors the licensor.

In the short run, including the option value in the reasonable royalty might increase expected payments by some infringers and, in turn, raise downstream prices in at least some markets. But that immediate effect is only part of the picture. Over the long run, a damages rule that better compensates patentees for the timing flexibility appropriated through infringement improves expected returns to innovation and reduces the degree to which implementers can free ride on patented technology. More important, the simulations indicate that including option value changes behavior as well as price. By making delay costly rather than free, the rule induces more firms to negotiate earlier, when borrowing costs are lower and agreement is more likely. The relevant trade-off, therefore, is not simply between higher and

lower royalties, but between a regime that subsidizes delay and litigation and one that encourages earlier contracting on terms that more closely reflect the full value transferred in the hypothetical negotiation.

The same logic also has an immediate implication for the use of comparable licenses. A reasonable-royalty analysis that relies on comparable licenses without accounting for differences in timing flexibility is incomplete, and, where those differences are material, wrong. A license negotiated *ex ante* for immediate payment is not economically equivalent to a hypothetical framework that permits the implementer to delay payment until uncertainty about commercial success has been resolved. If the latter arrangement confers a valuable option on the implementer, then a benchmark drawn from the former cannot be treated as directly comparable without adjustment. Courts should therefore ask not only whether the asserted benchmark involves similar technologies or market circumstances, but also whether it reflects a similar allocation of risk over the timing of the transaction. When it does not, the benchmark should be adjusted before it is used to infer the royalty upon which willing parties would have agreed in the hypothetical negotiation.

Ultimately, the same economic logic that shows why the traditional hypothetical negotiation can undercompensate the patent holder also explains why the proposed adjustment fits comfortably within the existing *Georgia-Pacific* framework, especially where courts must determine what rational parties would have agreed to and whether comparable licenses are truly comparable. The consequences for real-world patent litigation are therefore direct and substantial. A damages rule that prices the option to wait at zero invites delay. Rational firms will postpone licensing and license later only if the patented product proves worth pursuing and the patent holder successfully enforces its rights. That is not the bargain a willing licensor would have struck at the time of first infringement. Courts cannot reliably reconstruct that bargain by relying on comparable licenses that lack equivalent timing flexibility. Such licenses are not merely imperfect benchmarks; when the omitted flexibility is material, such licenses mismeasure the royalty required to compensate for infringement. Courts applying the reasonable-royalty framework should therefore require adjustments for differences in timing risk before treating a license as comparable. If existing doctrine is understood to prevent that adjustment, then the doctrine should change. Otherwise, patent damages will continue to leave uncompensated part of the value appropriated by infringement—precisely the gap that damages must fill when injunctive relief is unavailable.

Earlier negotiations will have other beneficial welfare effects not considered in this article. For example, transaction costs will increase if the patent holder must resort to litigation to assert its legal rights. Consequently, it

could be the case that the inclusion of the option value results in transaction costs.

Dynamic-welfare analysis also suggests potential gains from the inclusion of the option value within the reasonable royalty framework. Remedying inadequate compensation for patent holders will increase the expected return to patentable innovations. Increasing the expected return to patentable innovations will increase the market equilibrium investment in research and development. One way of viewing under-compensatory royalty rates is that those rates allow implementers to free ride on the investment of patent holders. Lessening the degree of free riding will also serve to increase the expected amount of investment in market equilibrium.

In addition, the inclusion of the real option within the calculation of a reasonable royalty could serve to simulate the practice of licensing actual real options to potential entrants. Such licensing would serve to reduce barriers to entry into downstream industries and increase levels of competition. The mere availability of an option to license could increase contestability without new entry and have beneficial effects of downstream welfare. The extension of this analysis to a dynamic model is the next logical step in this line of research.

In markets where the patent holder is subject to a commitment to offer licenses to its patents on FRAND royalty rates, additional analysis is required. Particularly the operation of the non-discriminatory prong of the FRAND commitment in conjunction with the inclusion of the option value merits further consideration.

Finally, one likely argument against the inclusion of the option value in the calculation of a reasonable royalty is simply that options are difficult to value and that such a valuation might not be possible in practice. To that argument, I would simply state that the ability to calculate an option value is likely a fact-specific inquiry that could vary from case to case, and that some courts regularly must apply option-valuation methods for financial options. However, if it is in fact impossible to calculate reliably the option value as a part of the calculation of a reasonable royalty and the patent holder cannot receive compensation for the harm created through the real option, then such harm is irreparable, and the appropriate remedy would be injunctive relief.

Conclusion

Would one ever put a quarter in a parking meter if the fine for illegal parking were $0.25? The most common remedy for patent infringement is a reasonable royalty, which is estimated as the outcome of a hypothetical negotiation at the time of first infringement. That is, the most common remedy

for infringement is the price the infringer would have paid absent the infringement. Such a remedy minimizes the incentive for a potential licensee to seek a license before infringement. In addition, the remedy grants to the infringer a valuable real option to infringe a patent and pay a royalty in the future roughly equal to the royalty that would be paid today. That royalty is paid *only if* (1) the infringement is discovered, (2) the potential royalty is significant enough to cover the transaction costs of licensing, and (3) the patent holder is successful in enforcing its patent rights.

In this article, I show how the reasonable royalty as traditionally calculated by U.S. courts is not "adequate to compensate for infringement" as required by the Patent Act,[48] and how the inclusion of the real option value rectifies the shortcomings of traditional damages calculations, fits within the existing legal framework for damages, and improves economic welfare. Simply put, the real option's inclusion contemplates a negotiation in which licensor and licensee negotiate over a license to start paying royalties at some point in the future, more closely aligning the negotiation with observed behavior. In addition to the expected gains from reducing the free riding on the patented innovation, the inclusion of the real option value of infringement within the hypothetical negotiation leads to increased rates of licensing early in the period of infringement, efficiently allocates risk between licensee and licensor, and reduces the costs of entry, increasing long-run economic welfare.

[48] 35 U.S.C. § 284.